CLAIMS

1. A method of image reconstruction comprising:

obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

determining a geometry associated with said obtaining of said Helmholtz reciprocal pair of images;

selecting a plurality of points in said first image and identifying corresponding candidate points in said corresponding reciprocal image;

matching a selected point of said plurality of points and a candidate point of said corresponding candidate points.

2. The method of Claim 1 wherein said obtaining includes:

capturing a first image of said image pair with a first receiver at a first optical center and a first source at a second optical center; and

capturing a second image of said image pair with at least one of said first receiver and a second receiver at said second optical center, and at least one of said first source and a second source at said first optical center.

3. The method of Claim 2 wherein at least one of said first receiver and said second receiver are cameras and at least one of said first source and said second source is a light source.

4. The method of Claim 1 wherein said determining includes:

establishing a position corresponding to a first optical center relative to said object;

establishing a position corresponding to a second optical center relative to said object; and

computing an epipolar geometry based on said first optical center and said second optical center.

5. The method of Claim 1 wherein said selecting includes:

selecting an epipolar line in said first image and a corresponding epipolar line in said corresponding reciprocal image based on an epipolar geometry;

selecting an adjacent pair of points on said epipolar line in said first image of said reciprocal pair of images;

applying an ordering principle based on said adjacent pair of points; and

selecting a candidate matching point on said corresponding epipolar line in said corresponding reciprocal image.

6. The method of Claim 1 wherein said matching includes:

computing a depth and a normal for a candidate point in said corresponding reciprocal image;

applying Helmholtz reciprocity;

predicting an intensity for said candidate point, based on a measured intensity of said selected point in a first image; and

comparing said predicted intensity with a measured intensity associated with said candidate point in said corresponding reciprocal image, forming an error based on said comparing;

refining said predicting based on said error.

7. The method of Claim 6 wherein said predicting is based on the equation:

$$\hat{I}_{2,1} = I_{1,2} \frac{\mathrm{n} \cdot \mathrm{v}_1 \|\mathrm{c}_2 - \mathrm{p}\|^2}{\mathrm{n} \cdot \mathrm{v}_2 \|\mathrm{c}_1 - \mathrm{p}\|^2}$$

where

$I_{1,2}$ denotes intensity measured at optical center $c_1$with source located at optical center $c_{2;}$

$\mathbf{n} \cdot \mathbf{v}_1$ denotes projection of the normal vector at point **p** in the direction of $\mathbf{v}_1$;

$\|\mathrm{c}_2 - \mathrm{p}\|$ denotes depth for optical center c_2 ; and

$\|\mathrm{c}_1 - \mathrm{p}\|$ denotes depth for optical center c_2 .

8. The method of Claim 6 wherein said predicting is in agreement with a BRDF associated with a point on said object corresponding to said selected point.

9. The method of Claim 6 wherein said predicting is independent of a BRDF associated with a point on said object corresponding to said selected point.

10. The method of Claim 6 wherein said predicting includes specularities in said reciprocal pair of images.

11. The method of Claim 6 wherein said predicting includes leveraging effects of shadows and occlusions to enhance robustness of said predicting.

12. The method of Claim 6 wherein said refining includes dynamic programming.

13. The method of Claim 6 wherein said refining includes a global nonlinear optimization algorithm.

14. The method of Claim 6 wherein said refining further includes establishing a parametric model and updating a parameter of said model.

15. The method of Claim 6 wherein said refining is compensated to mitigate effects of saturation or blooming.

16. A method of image registration with an object comprising:

obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

estimating a pose for said object;

predicting an estimated image corresponding to said pose and one image of said reciprocal pair of images;

comparing said estimated image with a corresponding actual image from said pair of images; and

refining said estimating a pose based on said comparing.

17. The method of Claim 16 wherein said obtaining includes:

capturing a first image of said image pair with a first receiver at a first optical center and a first source at a second optical center; and

capturing a second image of said image pair with at least one of said first receiver and a second receiver at said second optical center, and at least one of said first source and a second source at said first optical center.

18. The method of Claim 17 wherein at least one of said first receiver or said second receiver are cameras and at least one of said first source and said second source is a light source.

19. The method of Claim 16 wherein said estimating includes establishing an initial position and orientation in three-dimensional space for said object.

20. The method of Claim 16 wherein said predicting includes:

determining an intensity for a plurality of candidate points, based on a measured intensity of a corresponding plurality of selected points in a first image of said reciprocal pair of images.

21. The method of Claim 20 wherein said predicting is based on the equation:

$$\hat{I}_{2,1} = I_{1,2} \frac{\mathrm{n} \cdot \mathrm{v}_1 \left\| \mathrm{c}_2 - \mathrm{p} \right\|^2}{\mathrm{n} \cdot \mathrm{v}_2 \left\| \mathrm{c}_1 - \mathrm{p} \right\|^2}$$

where

$I_{1,2}$ denotes intensity measured at optical center $c_1$with source located at optical center c_2;

$\mathbf{n} \cdot \mathbf{v}_1$ denotes projection of the normal vector at point **p** in the direction of $\mathbf{v}_1$;

$\left\| \mathrm{c}_2 - \mathrm{p} \right\|$ denotes depth for optical center c_2 ; and

$\left\| \mathrm{c}_1 - \mathrm{p} \right\|$ denotes depth for optical center c_2 .

22. The method of Claim 20 wherein said predicting is in agreement with a BRDF associated with a point on said object corresponding to said selected point.

23. The method of Claim 20 wherein said predicting is independent of a BRDF associated with a point on said object corresponding to said selected point.

24. The method of Claim 20 wherein said predicting includes specularities in said reciprocal pair of images.

25. The method of Claim 20 wherein said predicting includes leveraging effects of shadows and occlusions to enhance robustness of said predicting.

26. The method of Claim 16 wherein said comparing includes determining an error based on a difference between a selected plurality of points on said estimated image and a selected plurality of corresponding points on said corresponding actual image.

27. The method of Claim 16 wherein said refining includes dynamic programming.

28. The method of Claim 16 wherein said refining includes a global nonlinear optimization algorithm.

29. The method of Claim 16 wherein said refining further includes:

establishing a parametric model; and

updating parameters of said model to improve agreement between said estimated image and said corresponding actual image.

30. A storage medium encoded with a machine-readable computer program code, said code including instructions for causing a computer to implement a method for image reconstruction, the method comprising:

obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

determining a geometry associated with said obtaining;

selecting a plurality of points in said first image and identifying corresponding candidate points in said corresponding reciprocal image;

matching a selected point of said plurality of points and a candidate point of said corresponding candidate points.

31. A computer data signal: said computer data signal comprising code configured to cause a processor to implement a method for image reconstruction, the method comprising:

obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

determining a geometry associated with said obtaining;

selecting a plurality of points in said first image and identifying corresponding candidate points in said corresponding reciprocal image;

matching a selected point of said plurality of points and a candidate point of said corresponding candidate points.

32. A system for image reconstruction comprising:

a means for obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

a means for determining a geometry associated with said obtaining;

a means for selecting a plurality of points in said first image and identifying corresponding candidate points in said corresponding reciprocal image;

a means for matching a selected point of said plurality of points and a candidate point of said corresponding candidate points.

33. A storage medium encoded with a machine-readable computer program code, said code including instructions for causing a computer to implement a method for image registration with an object, the method comprising:

obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

estimating a pose for said object;

predicting an estimated image corresponding to said pose and one image of said reciprocal pair of images;

comparing said estimated image with a corresponding actual image from said pair of images; and

refining said estimating a pose based on said comparing.

34. A computer data signal: said computer data signal comprising code configured to cause a processor to implement a method for image registration with an object, the method comprising:

obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

estimating a pose for said object;

predicting an estimated image corresponding to said pose and one image of said reciprocal pair of images;

comparing said estimated image with a corresponding actual image from said pair of images; and

refining said estimating a pose based on said comparing.

35. A system for image registration with an object comprising:

a means for obtaining a Helmholtz reciprocal pair of images of an object, said Helmholtz reciprocal pair of images comprising a first image and a corresponding reciprocal image;

a means for estimating a pose for said object;

a means for predicting an estimated image corresponding to said pose and one image of said reciprocal pair of images;

a means for comparing said estimated image with a corresponding actual image from said pair of images; and

a means for refining said estimating a pose based on said comparing.